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SOFC anode reduction studied by in situ TEM

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The Solid Oxide Fuel Cell (SOFC) is a promising part of future energy approaches due to a relatively high energy conversion efficiency and low environmental pollution. SOFCs are typically composed of ceramic materials which are highly complex at the nanoscale. TEM is routinely applied ex situ for studying these nanoscale structures, but only few SOFC studies have applied in situ TEM to observe the ceramic nanostructures in a reactive gas environment at elevated temperatures.

The present contribution focuses on the reduction of an SOFC anode which is a necessary process to form the catalytically active Ni surface before operating the fuel cells. The reduction process was followed in the TEM while exposing a NiO/YSZ (YSZ = Y_2O_3-stabilized ZrO_2) model anode to H_2 at T = 250-1000^{o}C. Pure NiO was used in reference experiments. Previous studies have shown that the reduction of pure NiO is a relatively rapid autocatalytic process. On the contrary, the reduction of NiO/YSZ is significantly slower, which indicates that the presence of YSZ inhibits the reduction of NiO. This study aims to obtain fundamental insight into this reduction mechanism and to explain the inhibitive influence of YSZ.

A Titan E-Cell 80-300ST TEM was used for the in situ work in combination with the chip-based Aduro heating holder from Protochips. Since the chip-based heating holder does not allow internal temperature measurements, and the since the temperature of the chips are only calibrated in vacuum, part of the presentation will focus on temperature calibration.